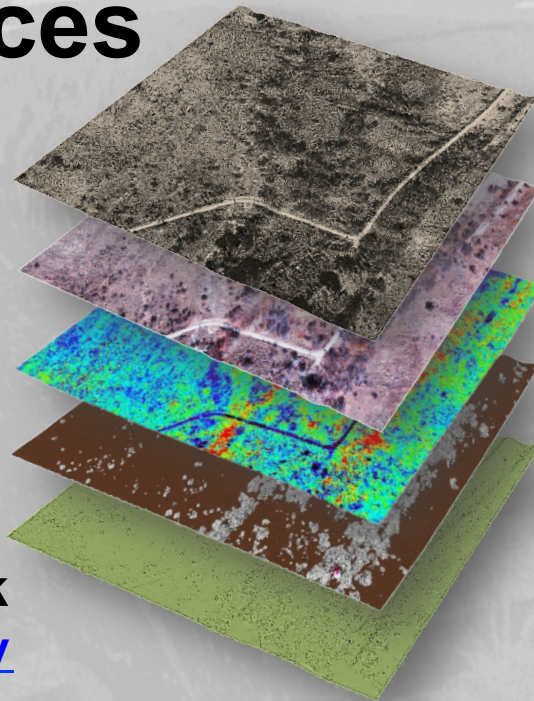


14th International Circumpolar Remote Sensing Symposium

Applying UAS Technology for Monitoring Wildlife and Natural Resources



Bruce K. Quirk
quirk@usgs.gov

September 15, 2016

Department of the Interior
U.S. Geological Survey

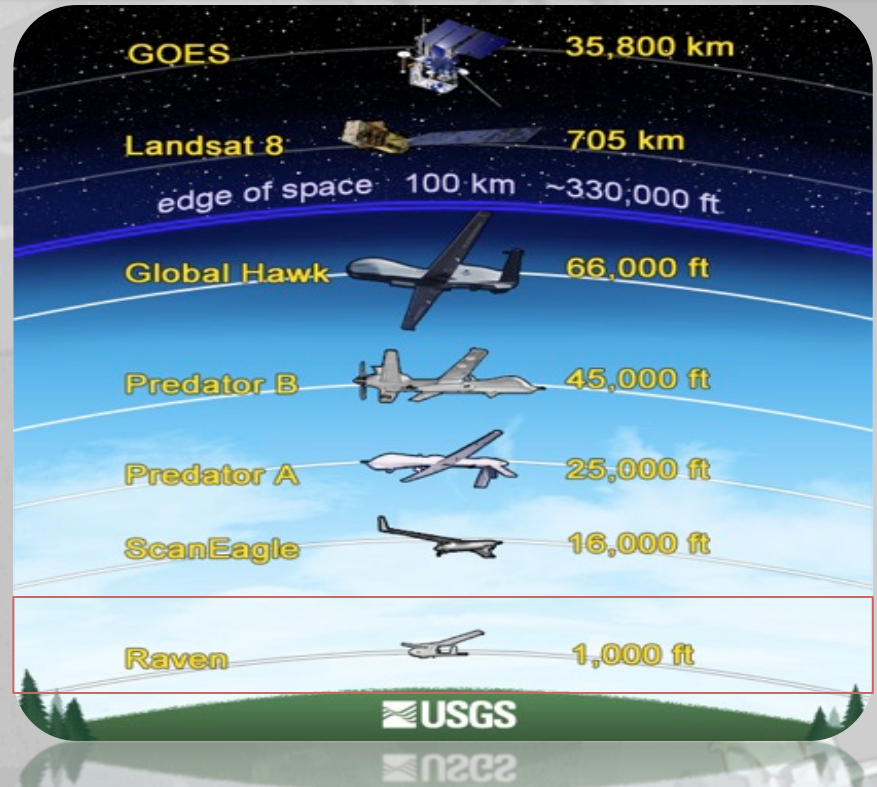
Why Use a UAS

Satellites provide periodic observations over regional/continental areas at low spatial resolutions

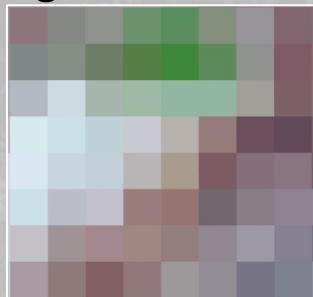
Manned aircraft can collect data over large spatial areas with a variety of sensors

Field surveys acquire many types of information over small spatial areas

UAS facilitate science driven remote sensing data acquisitions and compliment the other observations – “On-Demand Remote Sensing”



Its about the data!!



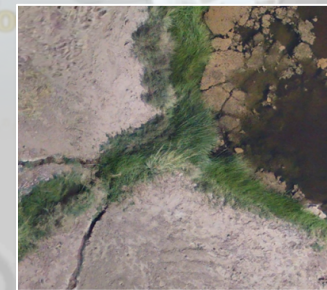
Landsat 8 (30 meter)



NAIP 2010 (1 meter)



UAS at 400 ft (5 cm)



UAS at 200 ft (2.5cm)

Lake Havasu, AZ



WorldView 2 – Multispectral (pan sharpened)

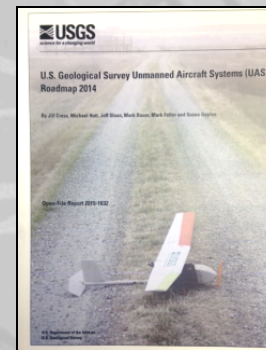


UAS – Canon s100 (modified blue filter)

USGS National UAS Project Office

Supports the technology transfer of UAS capabilities to enhance the informed decision making across the Department

- Established in 2008
- UAS missions with other DOI bureaus, the Office of Aviation Services (OAS) and other agencies
- Over 400 flights totally over 200 hours
- External contracting for UAS missions
- Evaluates emerging technologies
- Develops new products and capabilities
- USGS UAS Roadmap 2014
- USGS Leadership



DOI UAS Platforms

2009-2015



AeroVironment – Raven RQ-11A



Honeywell - T-Hawk



MLB Super Bat

Present



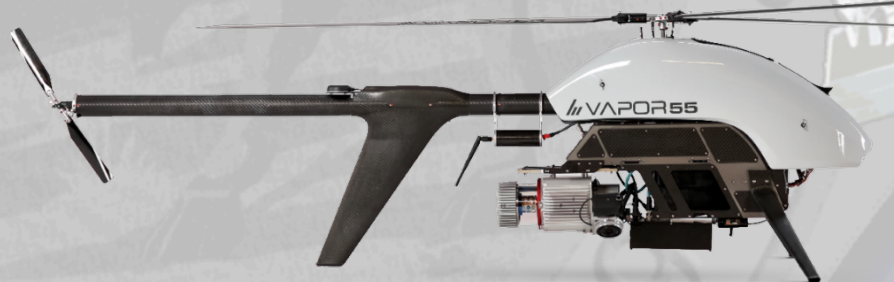
3DR Solo



Falcon Fixed Wing



Falcon Hover



Pulse Vapor 55

Existing Sensors

Point & Shoot or DSLR Cameras



HD Video



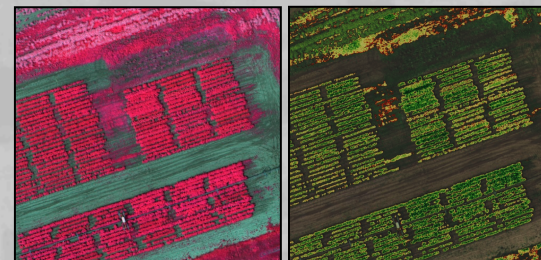
Calibrated Thermal



Courtesy of FLIR Tau 2 Sample Images



Multispectral



Courtesy of MicaSense Sample Images

Future Sensors

- Gas Sensors (SO₂,...)
- Radar
- Magnetometers
- Hyperspectral Sensors
- Natural Color Higher Resolution DSLR
- LiDAR
- Telemetry



DSLR



Magnetometers



LiDAR



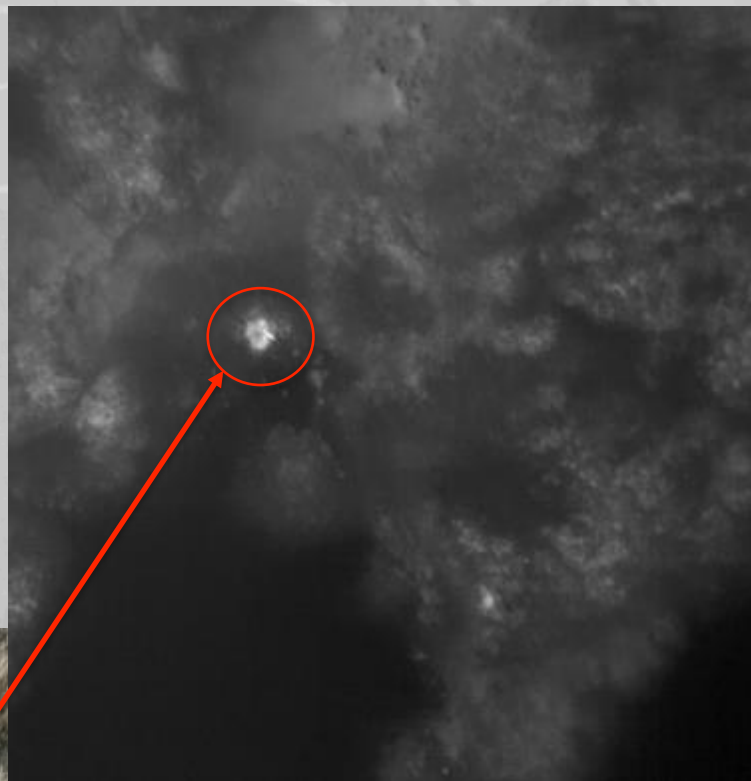
Hyperspectral

Thermal Sensor Testing

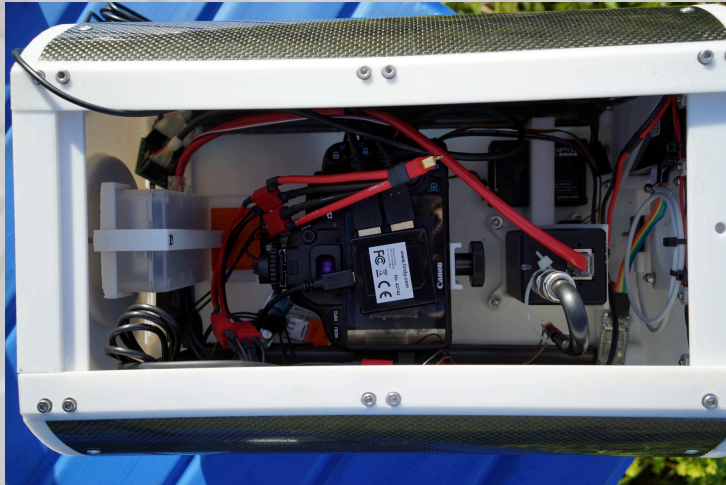
EO camera @400ft AGL from Canon s100
12MP still image of Trumpeter Swans



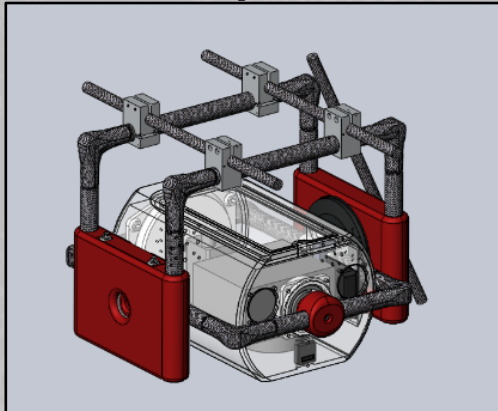
Tau640 thermal-IR @400ft AGL from RAW
14bit digital still of Trumpeter Swans with
“auto” histogram applied



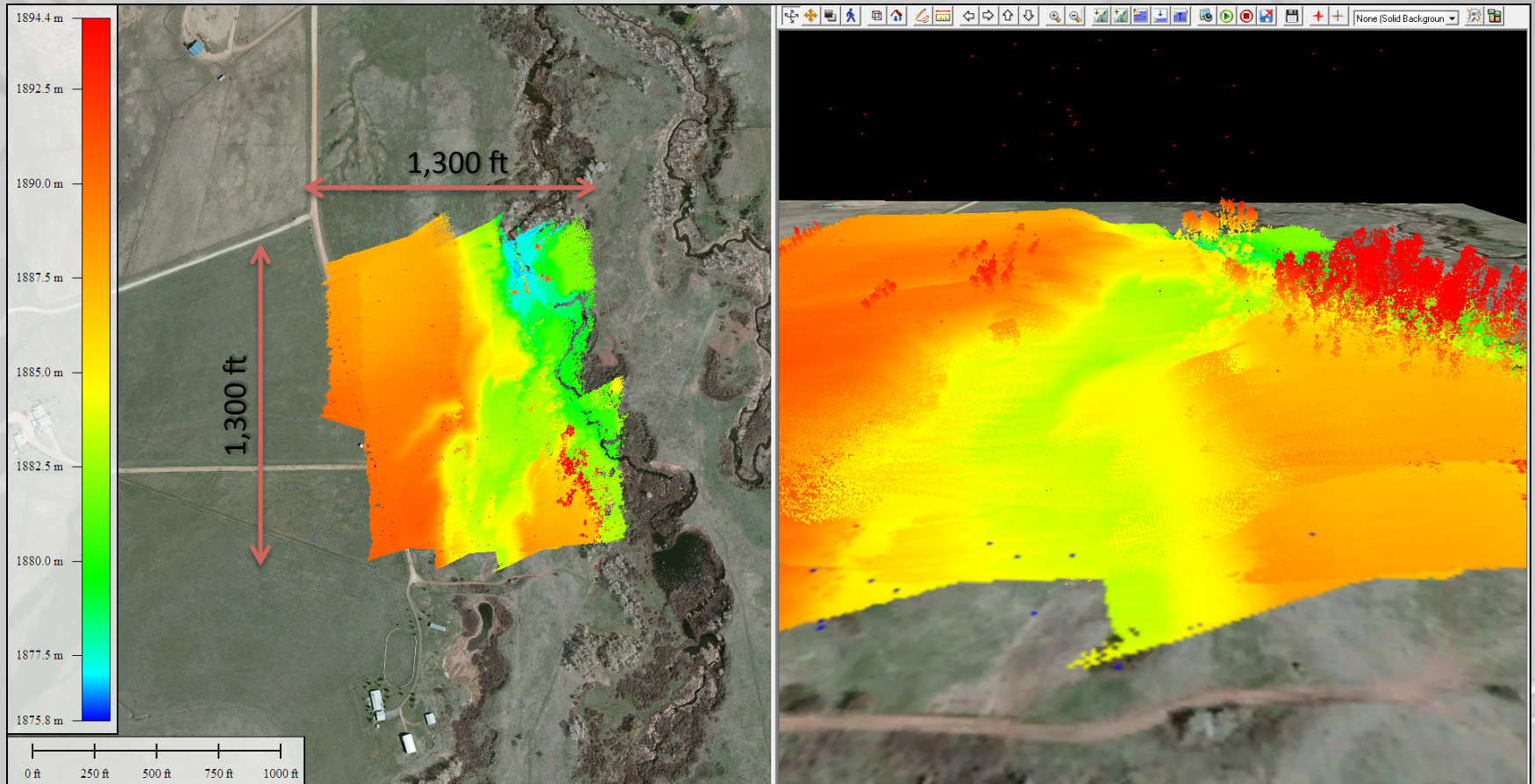
DJI S1000+ Octocopter



2-Axis Gimbal Setup



LiDAR Comparison



Sedalia, CO
May 9, 2016



Pulse Vapor 55 UAS



Multiple Payload Capability
(Simultaneous Data Collection)

UAS Applications

Wildlife Management

- Migratory Birds (Sandhill Cranes, Trumpeter Swans)
- Pygmy Rabbit Landscape Habitat
- Grizzly Bear Monitoring
- Elk Population Survey
- Sea Turtles
- Sage Grouse Inventory

Inspections-Mapping

- Fence, Pipeline, Power lines
- Mine Reclamation
- Vegetation - Invasive Surveys
- Archeological Site Surveys
- Environmental Survey - Palmyra Atoll
- Damage Assessments
- Easement Verification
- Volumetric Calculations

Public Safety

- Abandoned Mine Lands Survey
- Coal Seam Fire Detection
- Wildfire Incident Support
- Monitor Volcanic Activity
- Monitor Landslides
- Flood Mapping
- Law Enforcement Support

Research

- Assess Impacts of Dam Removal
- Hydrographic Survey
- Fire Science Research
- Monitor Forest & Rangeland Health
- River Bank Erosion Studies
- Geologic Resource Mapping
- Sensor & Imaging Processing

UAS 2015 Workshop Proposals

Tracking radio-tagged Asian Carp with Unmanned Aircraft System - Duane Chapman, Columbia Environmental Research Center, Columbia MO

Talus and microclimate mapping with UAS and airborne LiDAR to identify mechanisms of mammalian distribution - Aaron Johnston, Northern Rocky Mountain Science Center, Bozeman, MT

Landsat Dynamic Surface Water Extent (DSWE) Assessment - John Jones, Eastern Geographic Science Center, Reston, VA

Integration of unmanned aircraft systems and optical flow algorithms for remote sensing of water-surface velocity in rivers - Paul Kinzel, National Research Program, Golden, CO

UAS survey of water surface temperatures in the Bad River and Kakagon Sloughs, WI - Andrew Leaf, Wisconsin Water Science Center, Middleton, WI

Reservoir bathymetry from UAS during drawdowns of Fall Creek Lake, Oregon - Joseph Mangano, Oregon Water Science Center, Portland, OR

Effects of Changes in Tamarisk Evapotranspiration on Groundwater at a Southwestern Uranium Mill Tailings Site - Pam Nagler, Southwest Biological Science Center, Tucson, AZ

High-Resolution Aeromagnetic and Photogrammetric survey of the Mesquite Hills, CA - Geoff Phelps, Geology, Minerals, Energy and Geophysics, Menlo Park, CA; Skye Corbett, Geology, Minerals, Energy and Geophysics, Menlo Park, CA; Jeff Johnston, Geometric, San Jose, CA

Data collection at the West Fork mine - Joe Richards, Missouri Water Science Center, Rolla MO

UAS 2015 Workshop Proposals

Evaluation of UAS photogrammetry and comparison to ground and aerial surveys for monitoring geomorphic condition of fine sediment deposits along the Colorado River - Joel Sankey, Daniel Buscombe, Paul Grams, Southwest Biological Science Center and Grand Canyon Monitoring and Research Center, Flagstaff, AZ

Rapid-response mapping of coastal change - Chris Sherwood, Woods Hole Coastal and Marine Science Center, Woods Hole, MA

Mapping Channel Dynamics in Inter-dam Deposits - Katherine Skalak, National Research Program, Reston, VA

Assessing hydrologic function, plant stress, and success of bottomland restoration using UAS - Matthew Struckhoff - Columbia Environmental Research Center, Columbia, MO

Enhanced Variable Rate Irrigation using Thermal-Infrared-Imagery Acquired from Unmanned Aerial Systems in Southwest Georgia - Lynn Torak, South Atlantic Water Science Center, Norcross, GA

Elevation, IR and Visible Data Collection for a Hydrological Study at Farm Creek Marsh, Dorchester County, MD - Charles Walker, MD-DE-DC Water Science Center, Baltimore MD

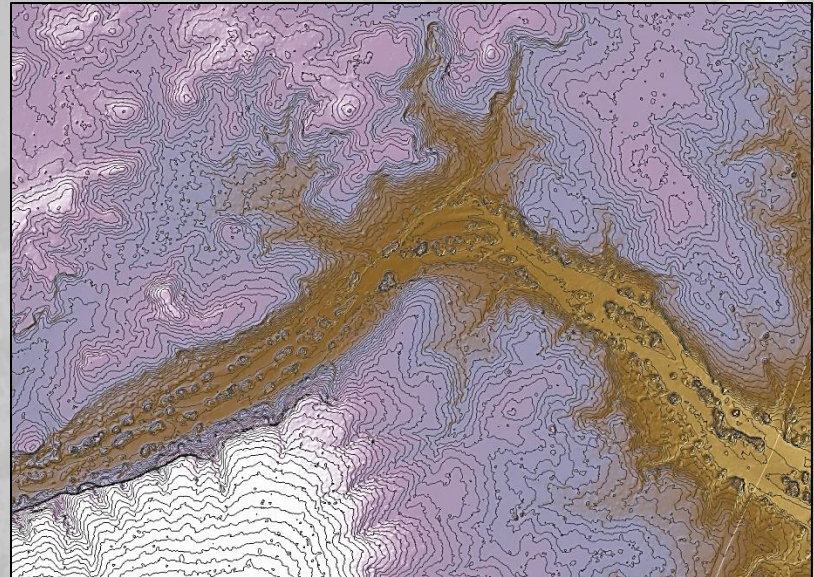
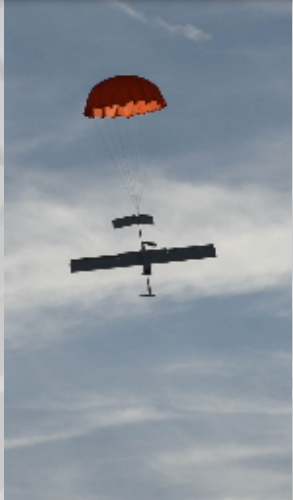
Mapping coastal cliff morphology and change with unmanned aircraft systems - Jonathan A Warrick, Pacific Coastal and Marine Science Center, Santa Cruz, CA

Identification and mapping of tile drains using thermal infrared imagery: transitioning low-altitude data to satellite-data method - Tanja Williamson, Indiana-Kentucky Water Science Center, Louisville, KY

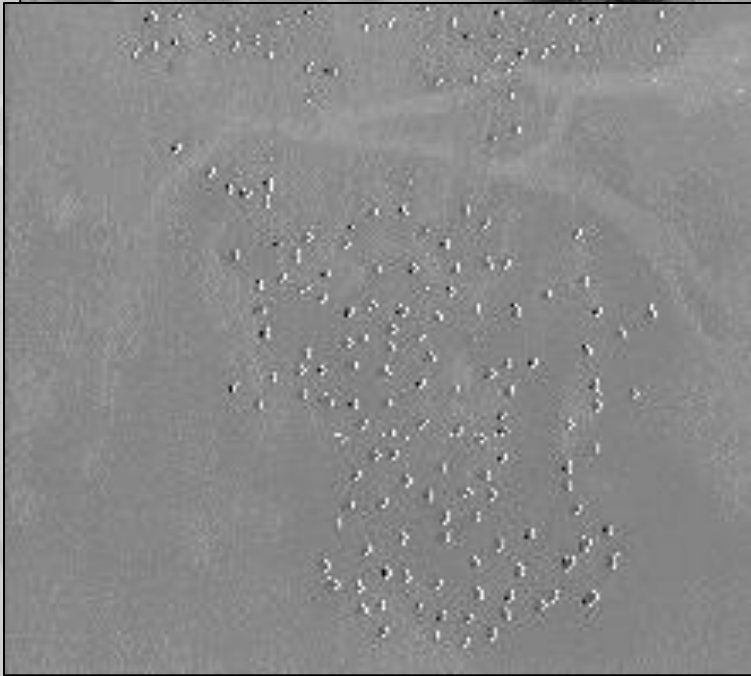
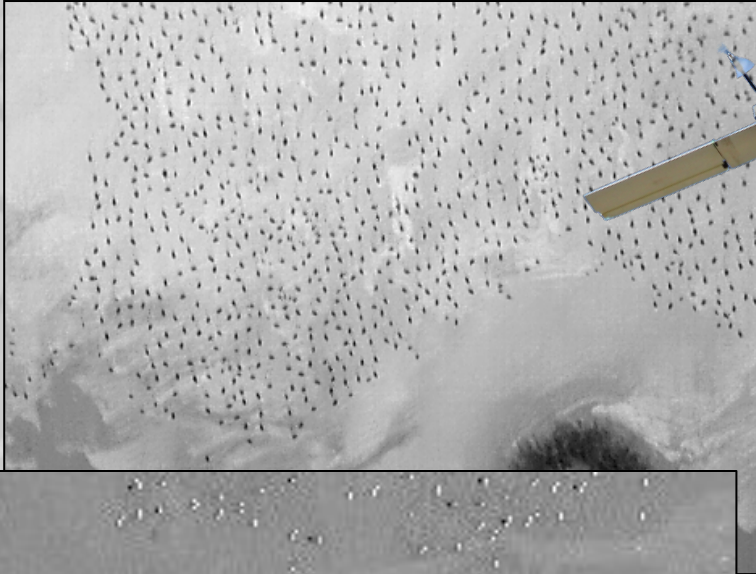
Using Unmanned Aerial Systems (UAS) for coastal monitoring in the Everglades— proof of concept - Scott Wilson, National Wetland Research Center, Lafayette, LA

Paleowetland Deposit Study Site

Mojave Desert, California

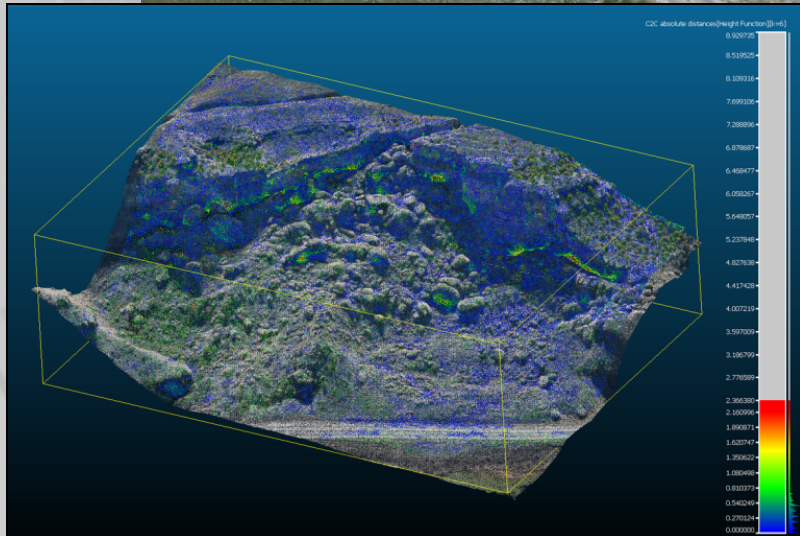
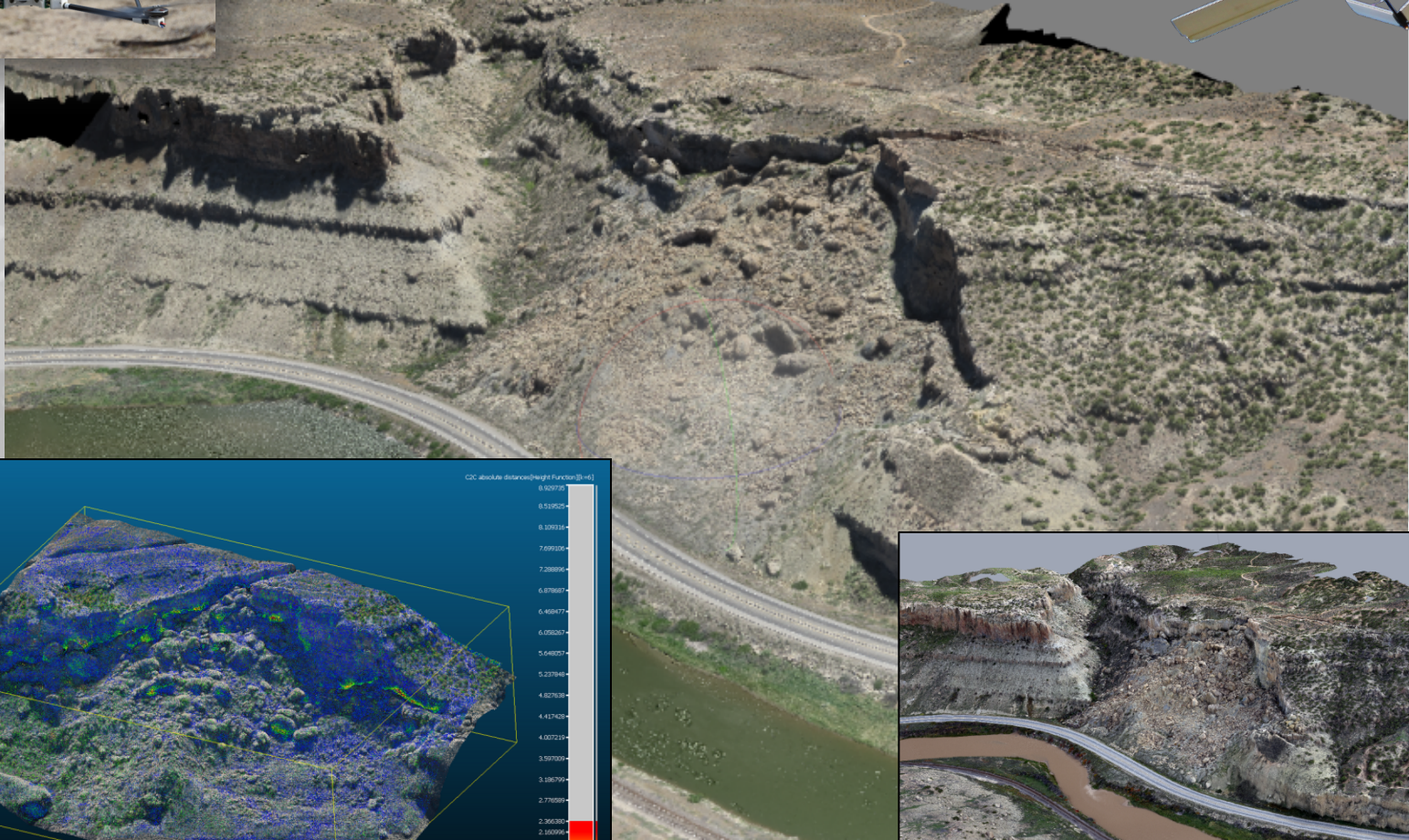


Migratory Bird Study - Sandhill Cranes at Monte Vista NWR Colorado



DeBeque Canyon Landslide

Western Colorado



Monitoring Mining Areas



Lead Mine Sinkholes, Missouri



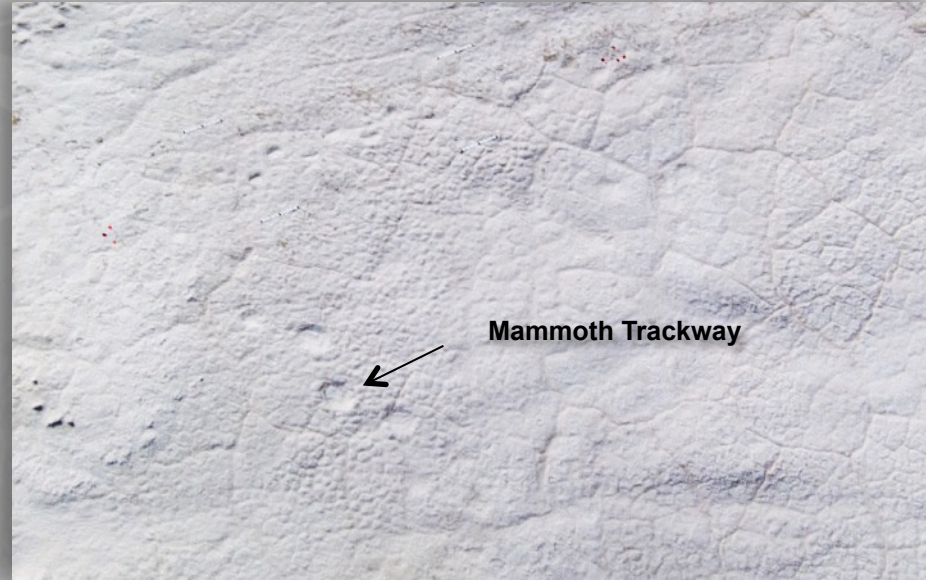
Abandoned Mine Lands, Colorado



Coal Mine Reclamation Monitoring, West Virginia

Pleistocene Trackway Mapping

White Sands National Monument, NM



Photogrammetric documentation using a UAS to aerial survey extremely fragile fossilized footprints from the late Ice Age

Theodore Roosevelt National Monument

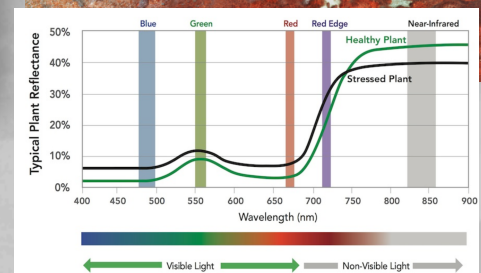
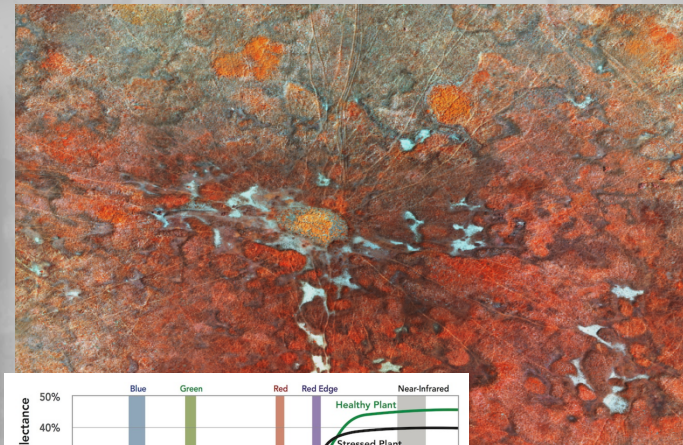
Medora, North Dakota



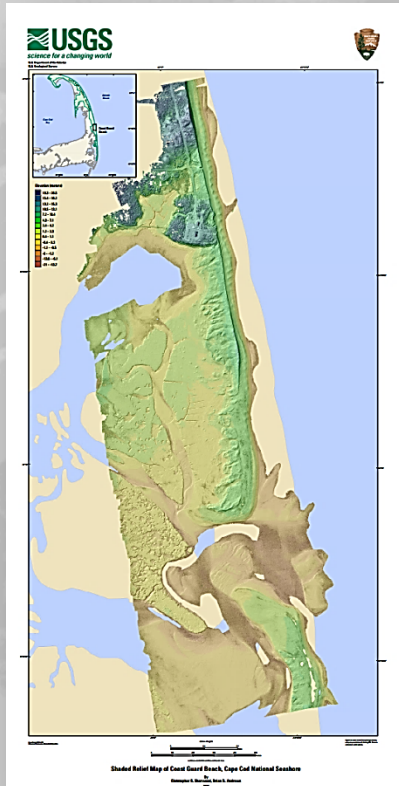
Sony A5100
Voigtlander Lens 15 mm
RGB (Bayer Filter)



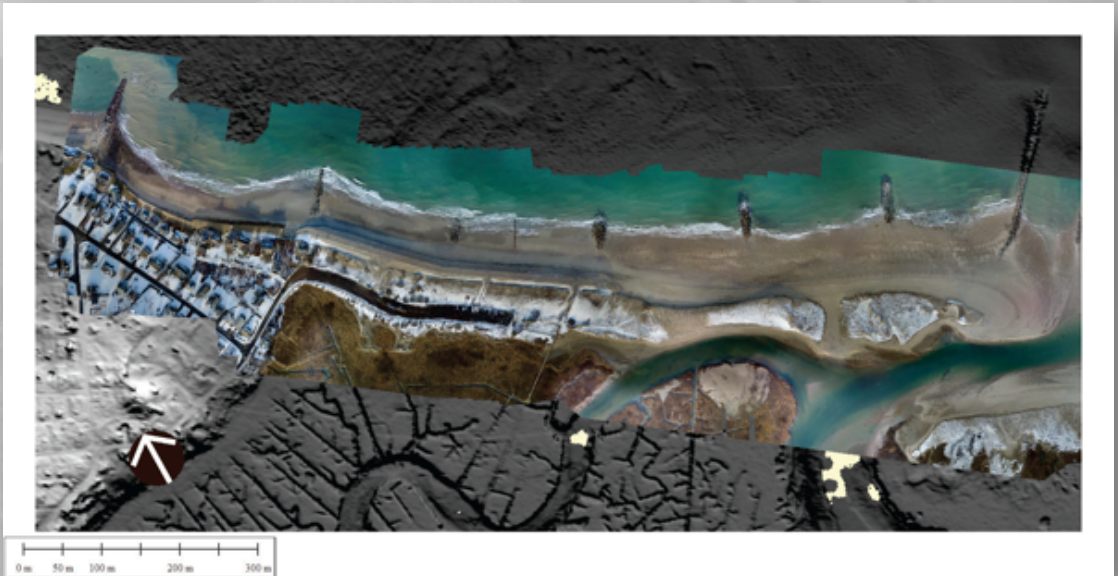
Micasense
Multispectral
RGB, NIR, Red Edge



Coastal Applications



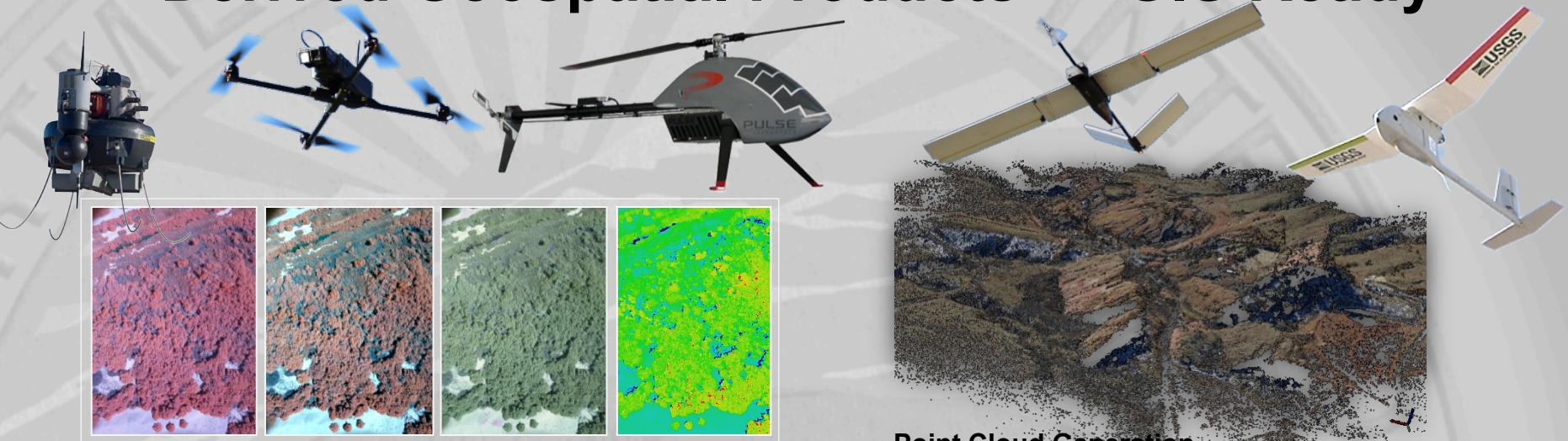
Shaded Relief Map of Coast Guard Beach
Cape Cod National Seashore
Sherwood & Andrews 2016



Overwash and erosion along beaches of Sandwich, Mass
Sherwood & Traykovski 2016

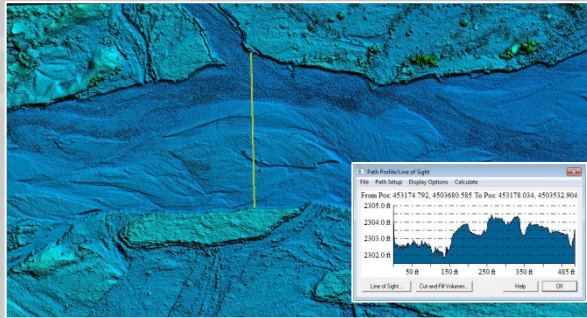


Derived Geospatial Products – “GIS Ready”



Color Infrared - NDVI

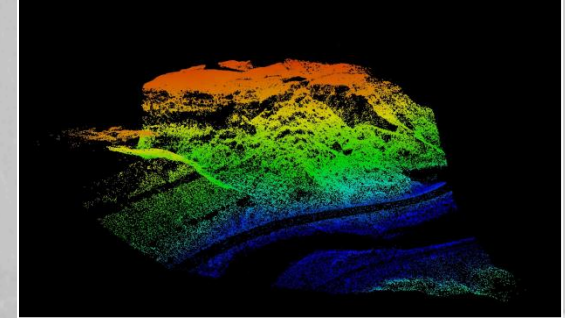
Point Cloud Generation



Elevation Models



Feature Extraction



Point Cloud Classification



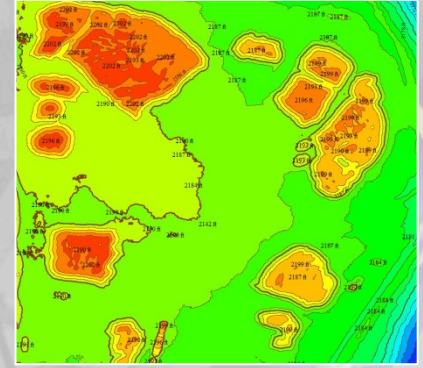
KML – 3D Modeling



Orthophotography



Volumetric Measurements



Contour Generation

UAS Data Processing

Color Infrared & Normalized Difference Vegetation Index (NDVI)

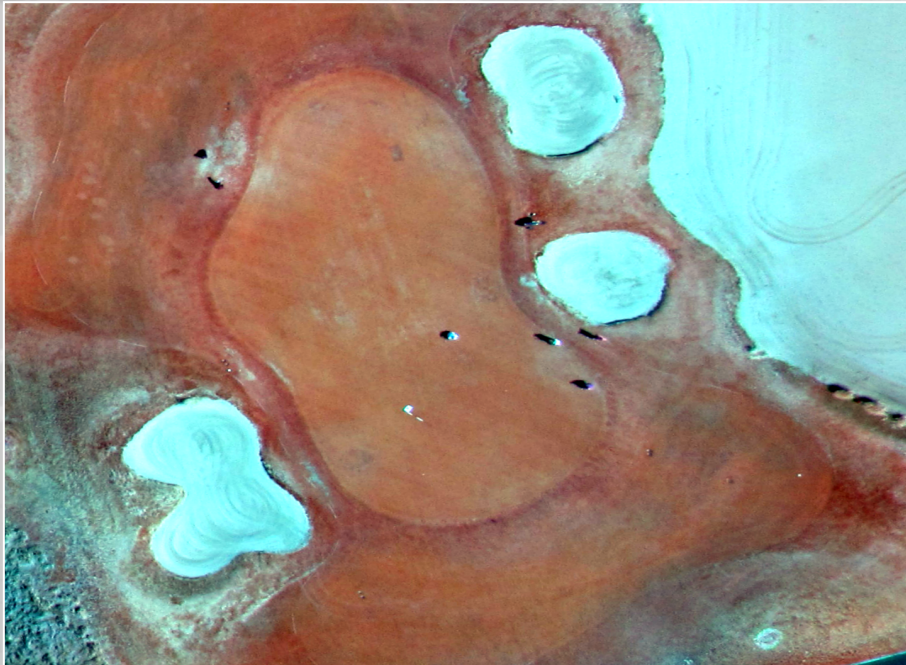
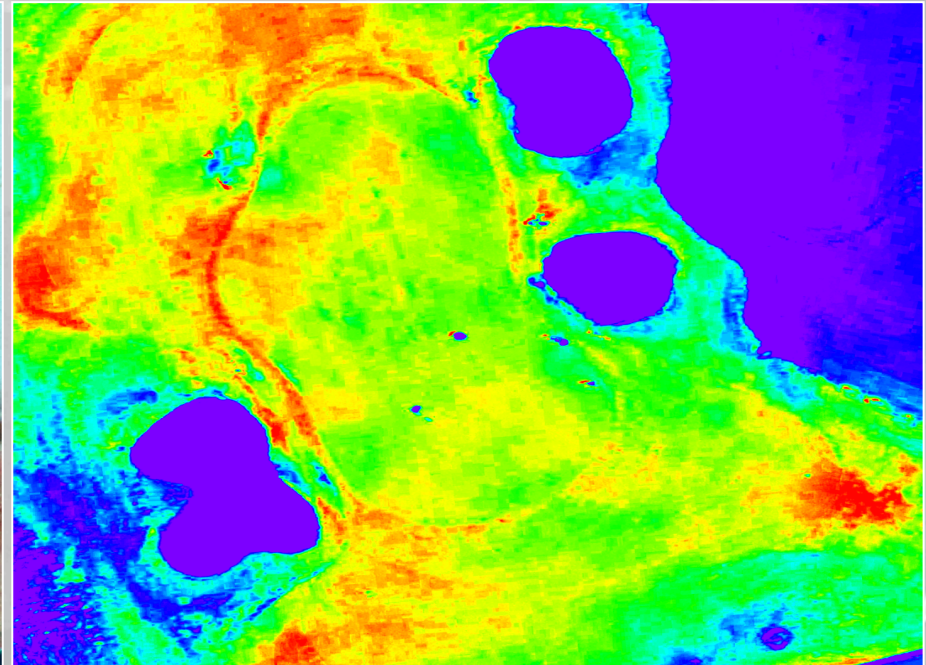


Image collected from UAS – Canon SX230 HS – 400'

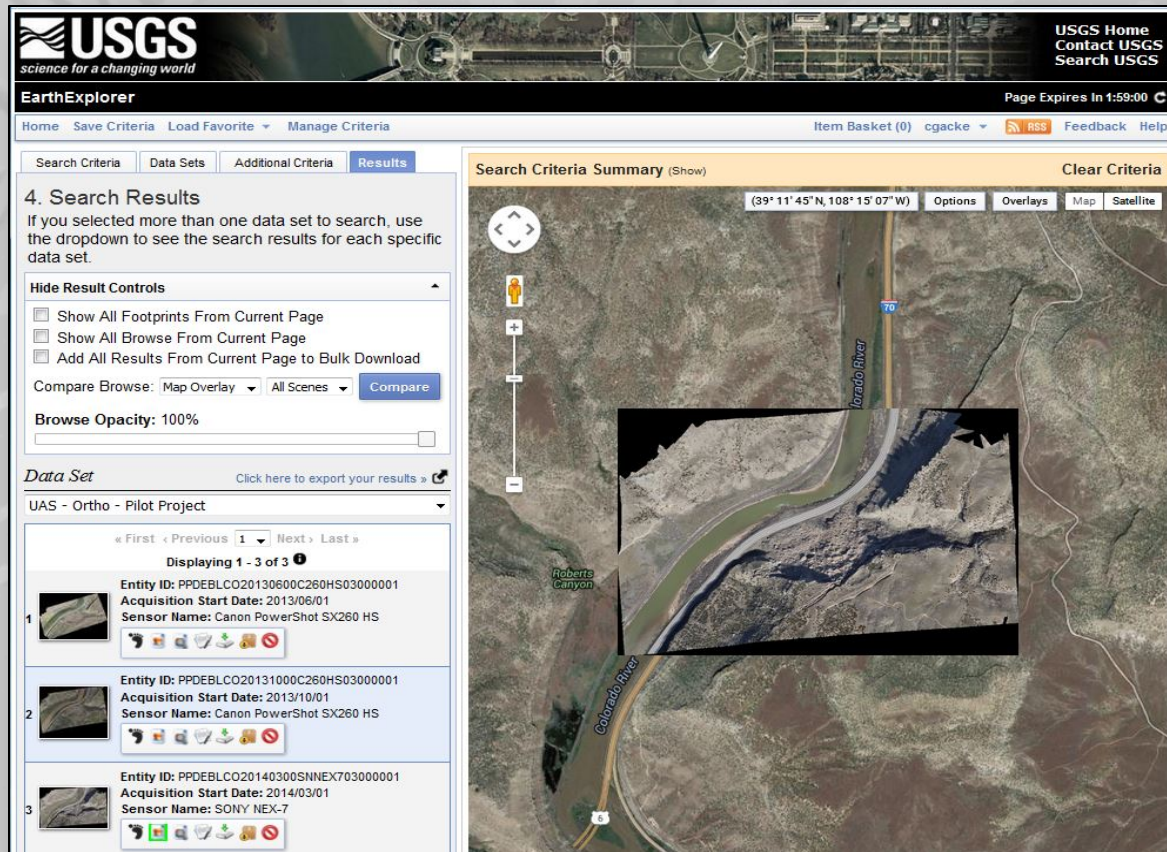


NDVI Low

NDVI High

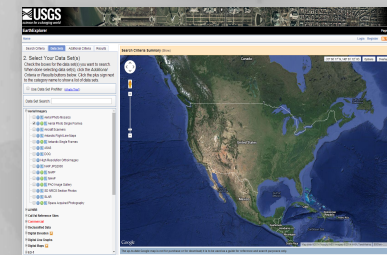
$$NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}$$

UAS Data Access & Distribution



The screenshot displays the USGS EarthExplorer website. The top navigation bar includes the USGS logo, "science for a changing world", and links for "USGS Home", "Contact USGS", and "Search USGS". The main content area is titled "EarthExplorer" and shows search results for "UAS - Ortho - Pilot Project". The search criteria summary indicates a location of (39° 11' 45" N, 108° 15' 07" W) and a search for "UAS - Ortho - Pilot Project". The results list three items, each with a thumbnail, Entity ID, Acquisition Start Date, and Sensor Name. The first item is Entity ID: PPDEBLCO20130600C260HS03000001, Acquisition Start Date: 2013/06/01, Sensor Name: Canon PowerShot SX260 HS. The second item is Entity ID: PPDEBLCO20131000C260HS03000001, Acquisition Start Date: 2013/10/01, Sensor Name: Canon PowerShot SX260 HS. The third item is Entity ID: PPDEBLCO20140300SNEX703000001, Acquisition Start Date: 2014/03/01, Sensor Name: SONY NEX-7. The map shows a satellite view of a river area with a search box and zoom controls.

Data lifecycle management



Privacy - Presidential memorandum on “Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems”

HAPS

- **High Altitude Pseudo-Satellite (HAPS)**
 - Airbus Zephyr UAV
 - Corning nanoSHARK hyperspectral sensor
 - NASA Ames, other sensors (TIR)
 - Spring 2017 workshop
 - Western U.S. flights (California)
- **Duration: days to weeks to months**
- **“Call for Ideas” to USGS scientists**
 - Received 11 ideas
- **NOAA & Solar Impulse**
 - CRADA
- **NOAA & NASA Langley studies**
- **Environmental Applications**



Summary

UAS technology is constantly changing creating issues in training, integration, certification, calibration, standards, but more complex sensors and systems are becoming available for scientific work

Regulations FAA, states and international – trying to catch up with the technology, looking forward to addition of BVLOS ops, etc.

USGS requires timely, high-quality, affordable data to meet its mission

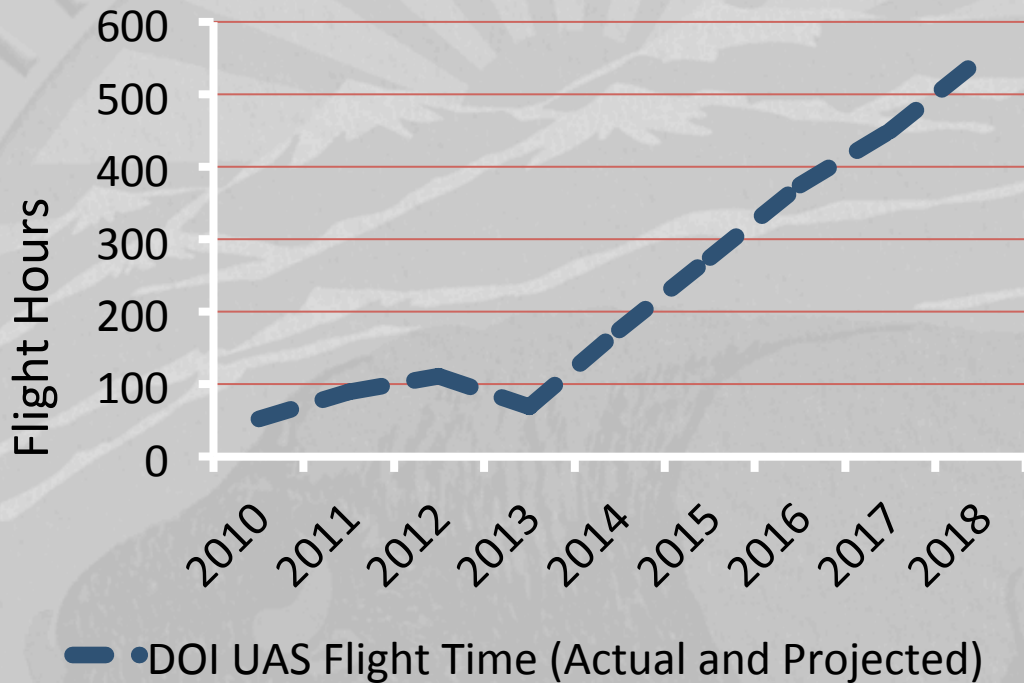
- Remote sensing is a key source of these data and UAS provide a flexible, low-risk and low-cost alternative – On Demand Remote Sensing
- Integration of satellite, UAS, in situ data/information
- Commercial options are becoming available, but

Collaboration/partnerships are important, connecting USGS scientists with NASA, NOAA, industry,...

- NOAA UAS for sensor calibration on JPSS & GOES-R

UAS will be a standard piece of field equipment for scientists

Thank you!



Website: <http://uas.usgs.gov/>



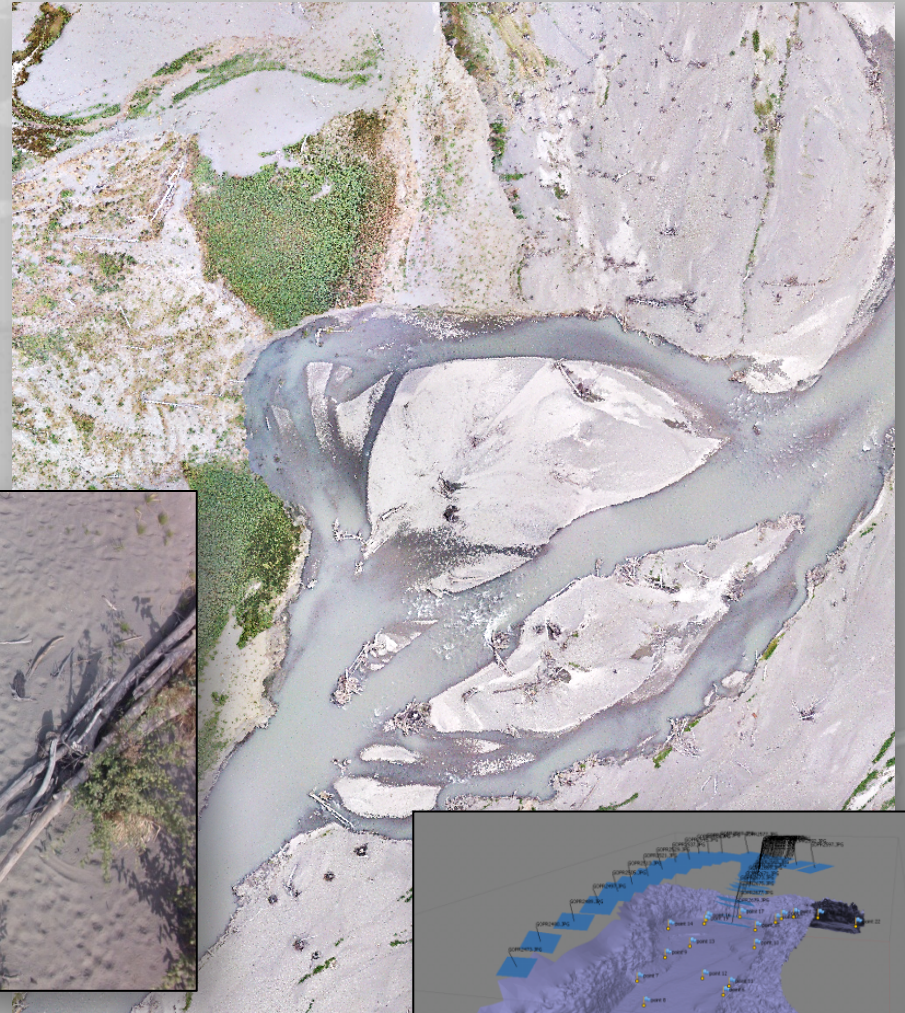
Autonomous underwater vehicle (AUV)

Monthly DOI UAS User call

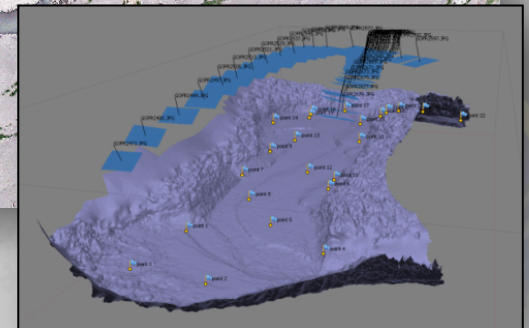
- Donna Delparte, Idaho State University, *Using Unmanned Aerial Systems to Assess Black-footed Ferret Habitat*

Elwha Dam Removal and River Restoration

Olympic National Park, Washington



Monitoring sediment volumes eroded from the reservoir and deposited downstream, where the mobile sediment can potentially affect salmon habitat



Ground Control

Circular



Cross

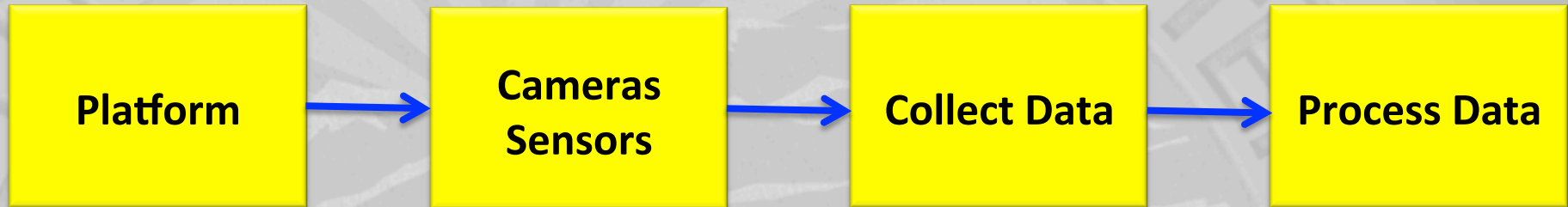


- Distribute your control points through out the edges of your study site. Pick a few in the center as well.
- If placing manually, set your GCPs markers on photos that have the target near the center of the photo. Pick the clearest, sharpest photos.



Future UAS system are introducing RTK hardware into the aircraft.

What are the Basic Costs?



\$1,000 - \$5000



\$20,000



\$40,000



\$300-\$1,200



\$2,000 - \$10,000



\$25 - \$75/hr



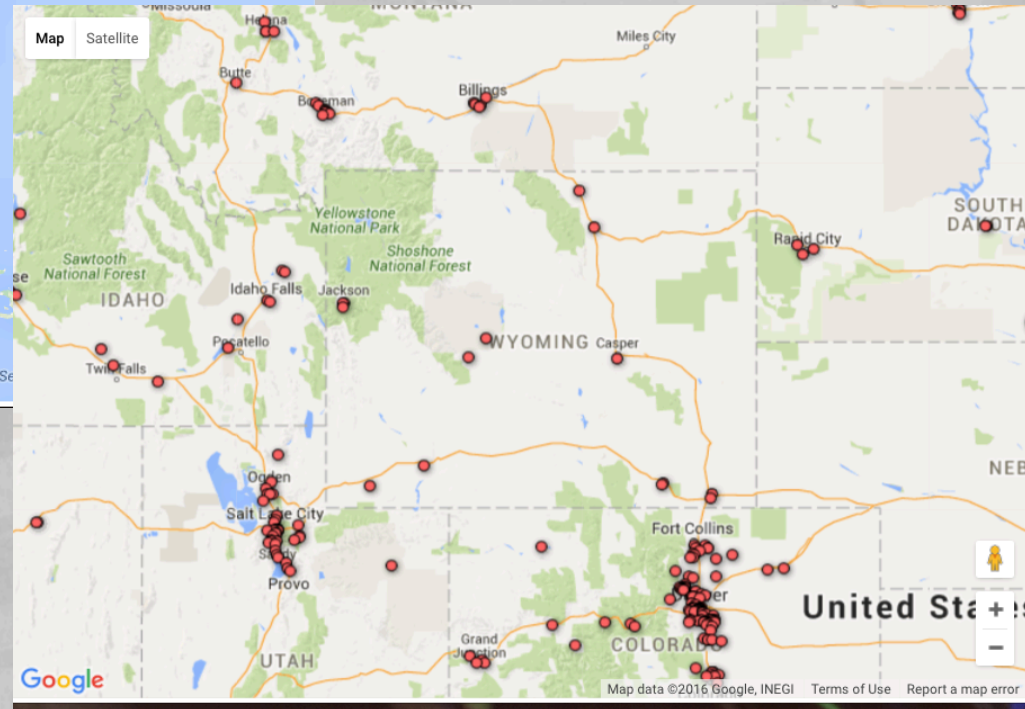
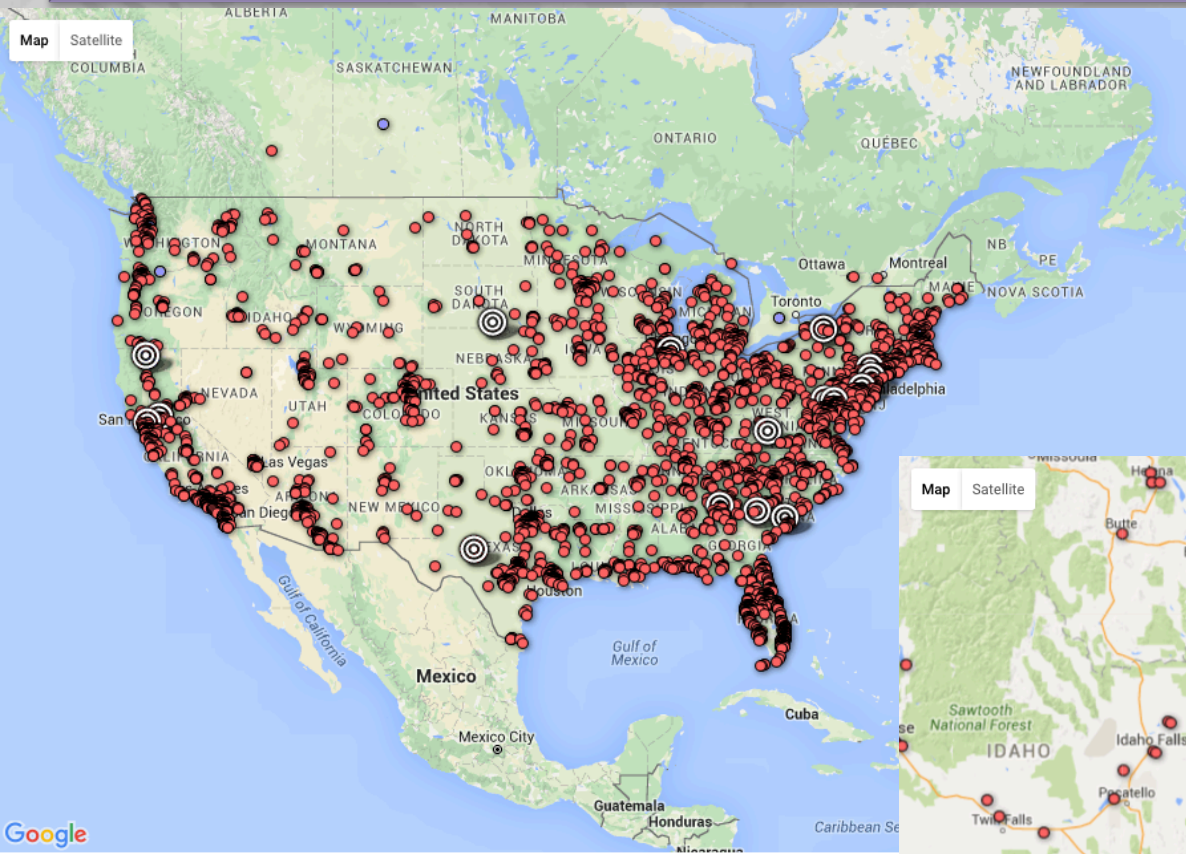
\$3,000



\$400

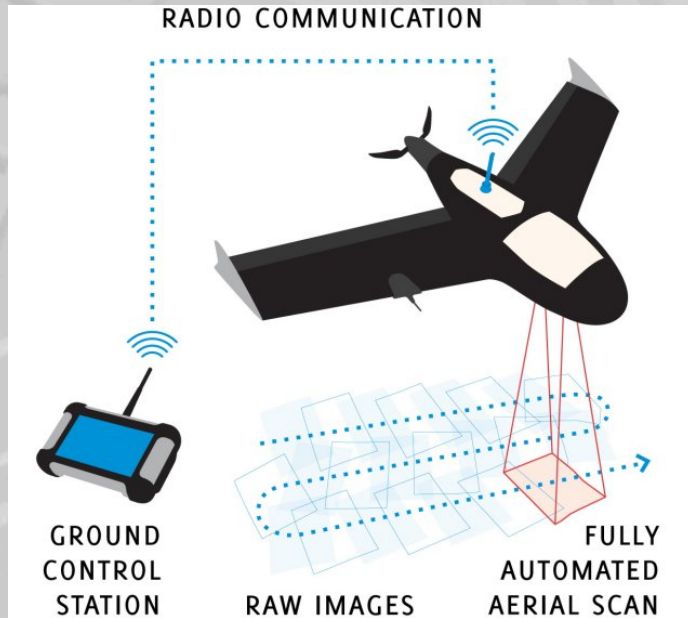


Contracting for Products



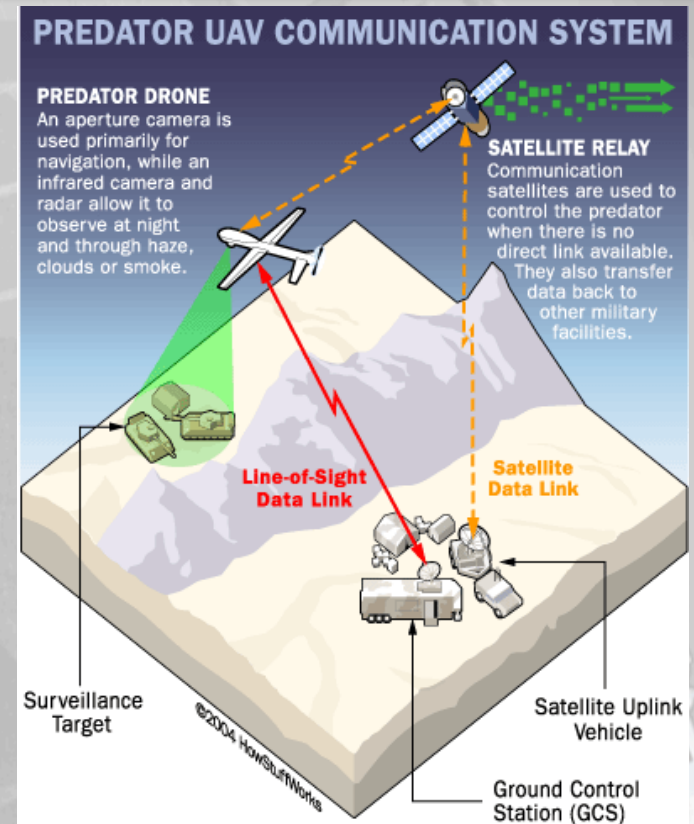
<http://www.suasnews.com/drone/exemptions333.html>

How a UAS Works



Visual-Line-of-Sight (VLOS)
DOI mode of operation

Sensors



Beyond-Visual-Line-of-Sight (BVLOS)

FAA and DOI



FAA - Develop and oversee Federal Aviation Regulations



Office of Aviation Services (OAS) - Develop and oversee overarching DOI policies and programs

**DOI OAS OPM-11
DOI Use of UAS**

Only OAS can purchase UAS



**Bureaus -
Develop
implementing
bureau policies
and programs**



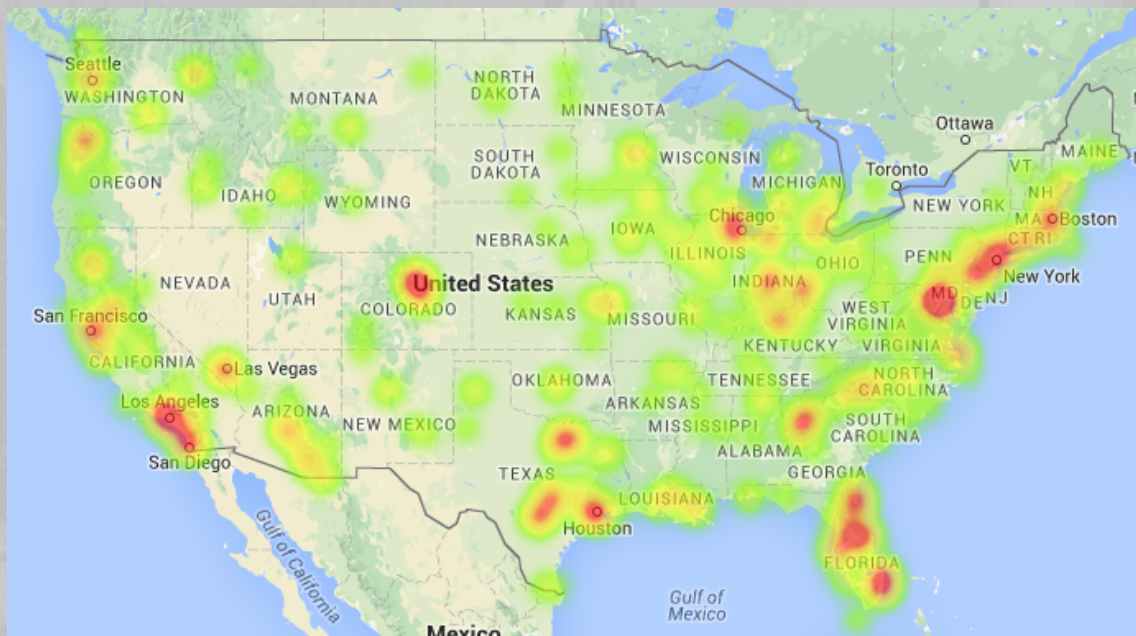
FAA and UAS

Congress included language and milestones requiring the integration of UAS into the National Airspace System (NAS) in the FAA Modernization and Reform Act of 2012, integration by September 30, 2015

FAA considers all UAS as “aircraft” (“Aircraft” means any contrivance invented, used, or designed to navigate, or fly in, the air. 49 U.S. Code § 40102)

Section 333 of 2012 Act – over 2400 exemptions for commercial work

1. Real estate
2. Aerial surveying
3. Aerial photography
4. Agriculture
5. Aerial inspection
6. Construction
7. Infrastructure inspection
8. Utility inspection
9. Film & TV





FAA and UAS (cont.)

Small UAS Notice of Proposed Rulemaking (NPRM)

- Proposed framework of regulations for commercial operations
- Available for public comments February – April 2015, > 4500 comments
- Final rule expected by June 2016

UAS registration

- Aircraft numbers
- User – task force plan submitted November 20

Where you can fly tools – <https://www.mapbox.com/drone/no-fly/>
B4UFLY – <http://www.faa.gov/uas/b4ufly>



FAA and DOI (cont.)

Memorandum of Agreement (MOA)

- Originally signed Dec. 24, 2013 (updated Sept. 2015)
 - Under 1,200'
 - Line of sight
 - 5 nm from an airport (control tower)
 - 3 nm from an airport (published instrument procedures)
 - 2 nm from an airport (not having published instrument procedures)
 - 2 nm from a heliport
 - Not over people or urban settings
 - NOTAM
 - VFR weather minimums and allowed to fly at night
 - File Certificate of Authorization (COA) 48 hours prior to mission – file and fly
- https://www.doi.gov/sites/doi.opengov.ibmcloud.com/files/uploads/DOI_FAA_MOA_Class_G_09112015.pdf